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**Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401**

General Technical
Report INT-128

July 1982

Fire-Climate Zones of Coastal Alaska

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THE AUTHOR

ARNOLD I. FINKLIN is a meteorologist at the Northern Forest Fire Laboratory. Specializing in climatology, he is currently with the Fire Effects and Use Research and Development Program. Previous assignments at this location were with Project Skyfire and the Fire in Multiple Use Research, Development, and Application Program. He received a bachelor's degree in meteorology at New York University, spent some years as a research aid at the University of Chicago, and received a master's degree in atmospheric science from Colorado State University, Fort Collins, before joining the Laboratory in 1967.

RESEARCH SUMMARY

This report presents a method for delineating fire-climate zones or areas; application is to coastal Alaska (Forest Service, Region 10). The method uses a multiple regression relationship calculated between a fire-danger parameter and simple climatic averages. The basic principle is to relate the zones to wildfire potential, utilizing data that provide maximum areal coverage. In the present case, the climatic averages were those of rainfall and daily maximum temperature for the May-August fire season. Fire danger was represented by the average seasonal number of days reaching a particular threshold value of the former Buildup Index. The regression, based on data from 18 stations, had a high statistical significance level. It was applied, as a series of curves, to the climatic averages at about 100 additional stations to give estimates of the fire-danger parameter. Fire-climate classes, comprising the fire-climate zones, were defined on the basis of this parameter.

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INTRODUCTION

The extensive forested areas of coastal Alaska (Forest Service, Region 10) have in the recorded past experienced generally minor wildfire occurrence, particularly when compared with that in mainland (interior) Alaska and the lower 48 United States. The maritime influence on the general climate is an obvious tempering factor with respect to fuel moisture, although large spatial differences do occur. Moreover, there is a near absence of lightning activity; wildfire ignition is thus confined, with rare exceptions, to locations of human presence.

Fire-management planning in this region, nevertheless, is presented with a somewhat difficult problem (Noste 1969). Severe burning conditions have occasionally occurred in the past few decades, even in normally wet areas. Thus, while the fire load is usually light, a capability must exist for handling the exceptional situations. A continuing expansion in the human presence, through recreational and logging activities, threatens to bring a more serious fire problem in the future. Contributing, also, would be the accumulating masses of untreated logging slash, which can dry quickly during recurring spells of warm, dry weather.

Fire-management planning has sought to concentrate attention on those areas where the wildfire potential, as influenced by climate, is greatest. Toward this policy, three broad fire-weather zones were devised in Region 10.[1] Though fire danger is monitored, less planning effort is expended with increasing wetness of climate. The present report results from a need expressed for further development and refinement of a fire-danger climatology. It is a condensed, updated version of a preliminary office report.[2] The purpose here is to present a method of defining fire-climate classes, employing a parameter of fire danger and simple climatic averages in a multiple regression. These classes are then applied in delineating fire-climate zones for coastal Alaska.

[1]U.S. Department of Agriculture, Forest Service, Revision of R-10 fire danger rating. On file at USDA Forest Service Regional Headquarters, Juneau, Alaska.

[2]Finklin, Arnold I. 1977. Fire-season climatic zones of coastal Alaska. Office report on file at Northern Forest Fire Laboratory, Missoula, Montana.

REVIEW OF RELATED WORK

Fire-climate zones or areas have been the subject of several specific studies in the past decade. Their use is included in proposals (Reifsnyder 1978) addressed to worldwide interests in fire management.

"Fire-season climatic zones" were delineated for mainland (interior) Alaska by Trigg (1971). A mosaic containing 25 zones, based on 16 climate-description classes, was developed. The climate classes were derived from modified Thornthwaite precipitation effectiveness and temperature efficiency indices, computed for a 6-month season. The basic input data were monthly precipitation and average daily maximum temperature at 48 stations.

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10-year period, 1956-65. The indices (part of the former National Fire-Danger Rating System) were computed for 11 airport stations and a lighthouse station. Noste (1969) found a relationship between these indices and size class of acreage burned. As indicated earlier, three fire-weather zones were defined for this region (see footnote 1). The zones were characterized according to April-July average precipitation and the average number of days with BUI as high as 30 and 60. The BUI data were from the above 12 stations plus fire-weather stations with shorter records. A BUI value of 30, it was said, could cause suppression problems for a fire in logging slash; at a value of 60, a fire in uncut timber would also be a problem.

DESCRIPTION OF THE REGION; FIRE OCCURRENCE

The geographic region referred to here as coastal Alaska (fig. 1) is divided into two broad areas. These correspond to the general locations of the Tongass National Forest (the southeastern Alaska panhandle) and the Chugach National Forest (the Kenai Peninsula and adjacent south coast, including Afognak Island). The southeast, comprised largely of a group of islands (the Alexander Archipelago), has been described in detail by Harris and others (1974); Federal Power Commission and USDA Forest Service (1947).

The topography of coastal Alaska can be characterized as mountainous and glaciated; though the highest elevations, reaching 7,000 ft (2 000 m) to well over 10,000 ft (3 000 m), are on the eastern and northern borders of the region. Mountains are generally low on the southeastern islands, allowing a vast expanse of forest from tidewater to a timberline near 2,500 to 3,000 ft (750 to 900 m). Stands here are primarily western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), with scattered western redcedar (*Thuja plicata*) and Alaska cedar (*Chamaecyparis nootkatensis*). The timberline decreases to 1,000 to 2,000 ft (300 to 600 m) in the Chugach area. Black spruce (*Picea mariana*), white spruce (*Picea glauca*), and paper birch (*Betula papyrifera*) are important species, and the ones with most fire occurrence, on the Kenai Peninsula (Noste 1969).

Annual precipitation over the region (fig. 2) shows the effects of topography, as well as prevailing storm tracks. Normal amounts near sea level range from about 15 inches (375 mm) on the west side of the Kenai Peninsula (outside the Chugach boundary) to more than 100 inches (2 500 mm) over much of the south coast and panhandle; 200 to 250 inches (5 100 to 6 300 mm) occur at a few locations. Amounts are down to 25 to 30 inches (625 to 750 mm) in the extreme northern interior of the panhandle (outside the Tongass boundary). The warmer months of late spring and summer are generally a relatively dry time of year, though normal monthly rainfall may well exceed 5 inches (125 mm) in the wetter areas, particularly in August; drier areas receive 1 to 2 inches (25 to 50 mm). Average daily maximum temperatures generally reach 60° to 65° F (16° to 18° C) by June or July, approaching 70° F (21° C) at some interior locations.

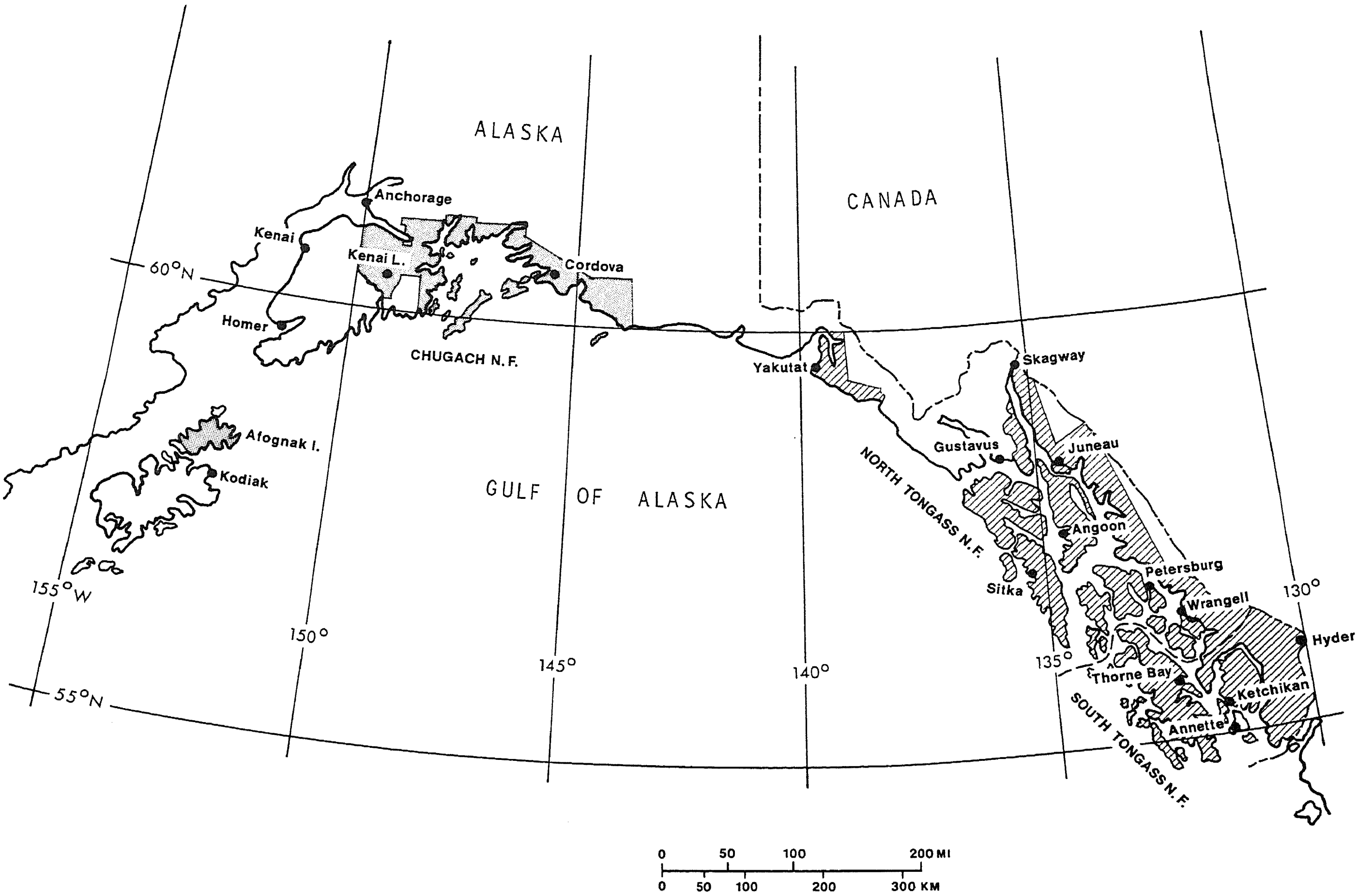

Figure 1.—Map of coastal Alaska (Forest Service, Region 10), showing locations of Chugach and Tongass National Forest (areas highlighted by shading and hatching).

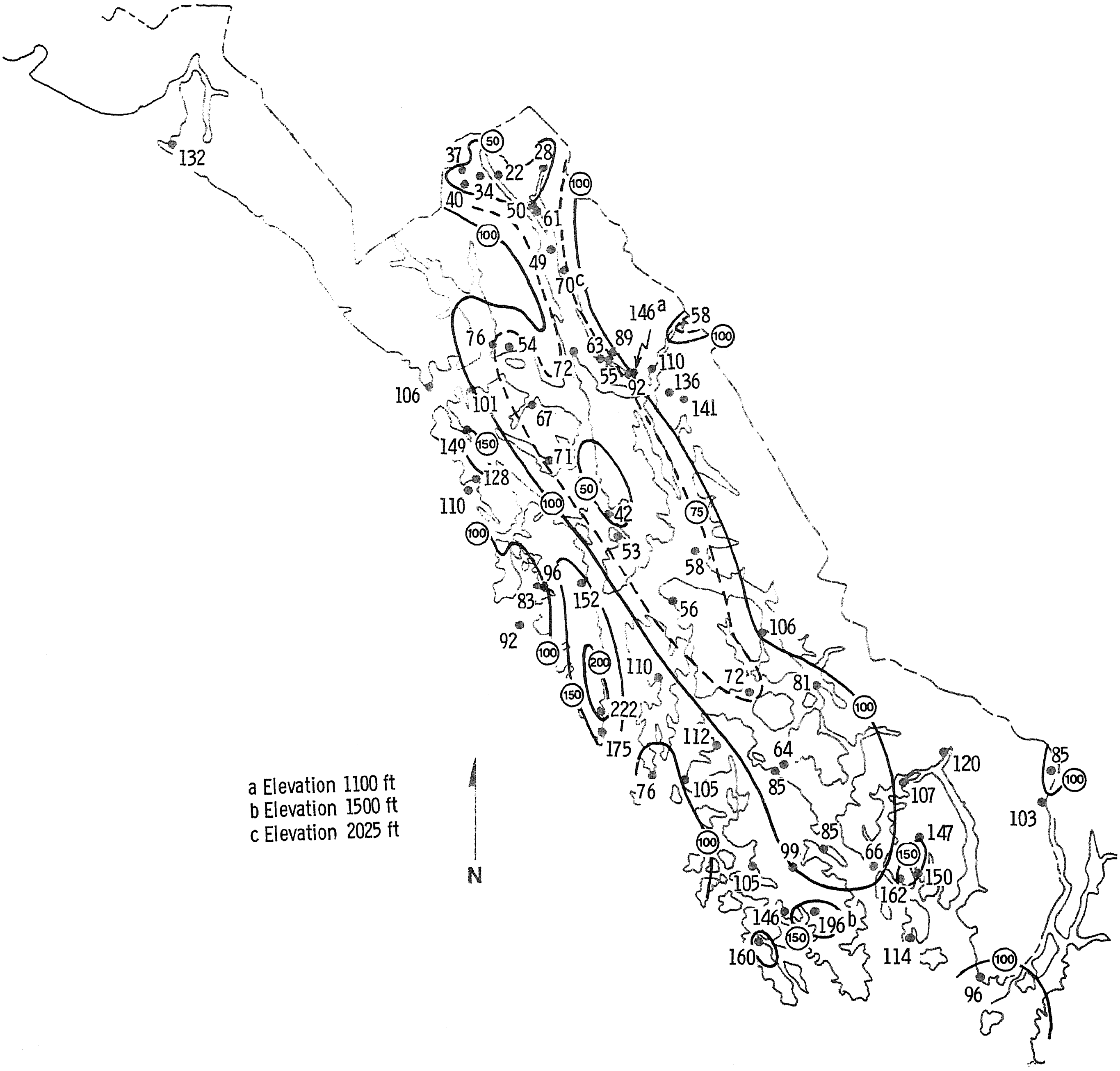

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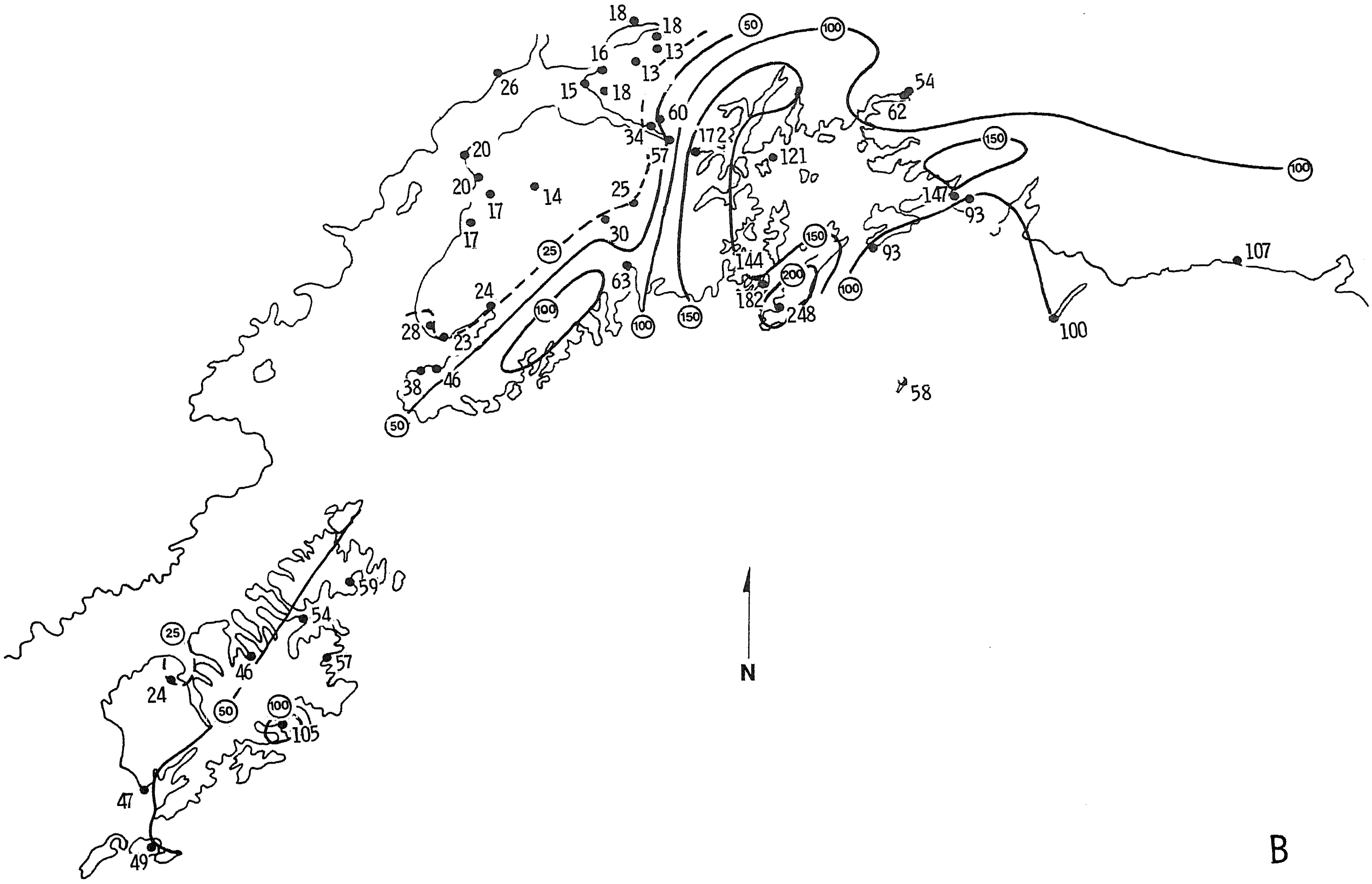
Figure 2.—Average annual precipitation, inches, at stations in coastal Alaska. Mostly based on or adjusted to normal period 1941-70. Solid lines are generalized isohyets drawn at 50-inch intervals; dashed lines are drawn at intermediate 25-inch intervals. Panel A: southeastern panhandle; panel B: Kenai Peninsula and south coast area.



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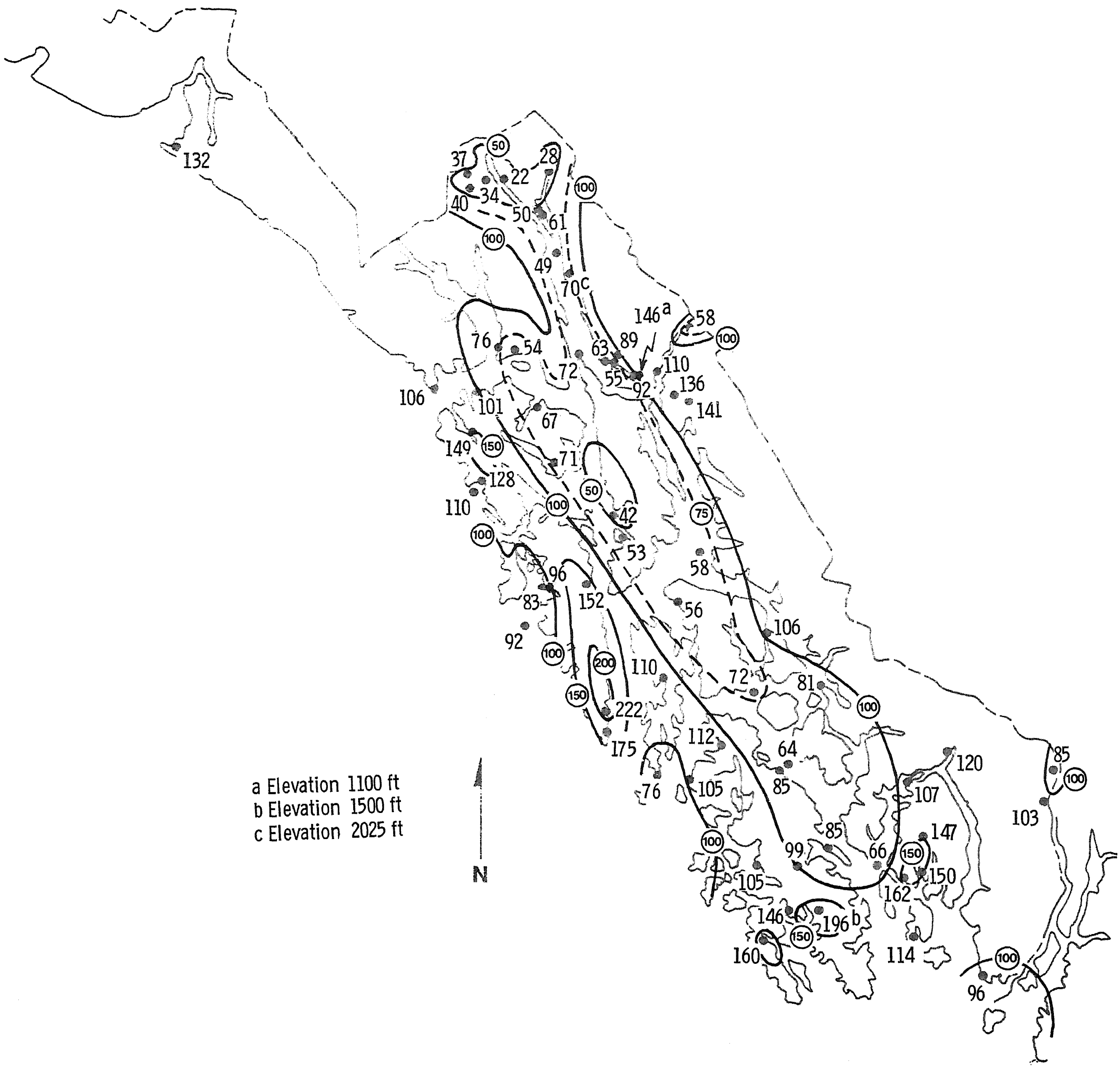

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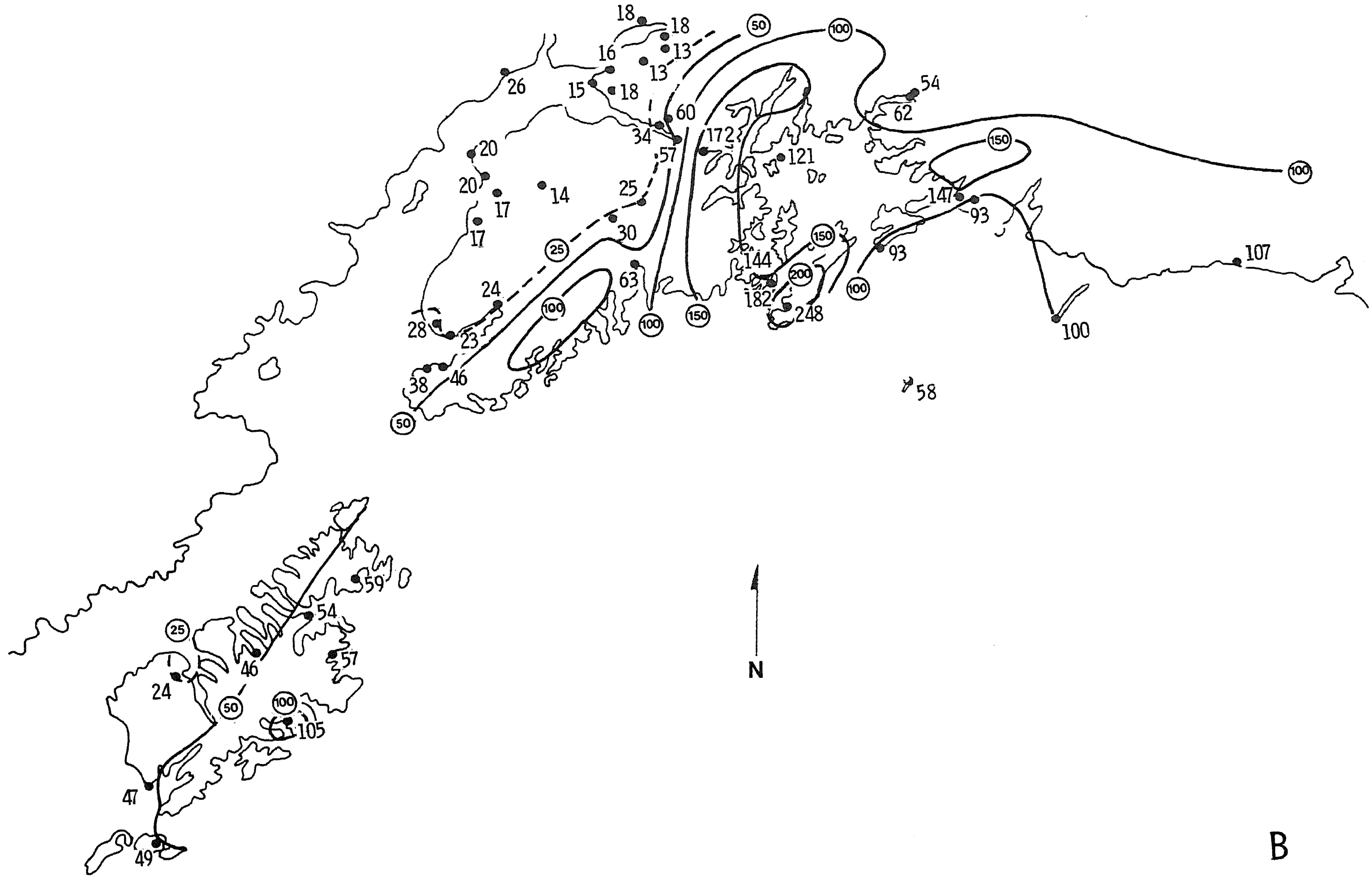
Figure 2.—Average annual precipitation, inches, at stations in coastal Alaska. Mostly based on or adjusted to normal period 1941-70. Solid lines are generalized isohyets drawn at 50-inch intervals; dashed lines are drawn at intermediate 25-inch intervals. Panel A: southeastern panhandle; panel B: Kenai Peninsula and south coast area.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The main fire season thus covers the period May through August. Overall, in Region 10, these 4 months account for about 80 percent of all wildfire occurrences and 97 percent of the total acreage burned (Noste 1969). In each of these months, there is commonly a period of a week or more with little or no rainfall. On weather maps, these periods are usually identified with persisting upper-air ridges or patterns of airflow from the north or northeast, which also bring higher daytime temperatures and lower relative humidity. Such features cover large areas; both the normally wetter and drier locations are affected. At some time during an average season, there is apt to be a dry spell of between 10 and 20 days over most of the region (fig. 3). Dry-spell duration reached 37 days at Skagway in 1971. A spell of 23 days in the same year at normally moist Ketchikan brought extremely high fire danger and a shutdown of nearby logging operations; a 65-acre (26 ha) fire occurred 2 miles (3 km) to the southeast.

Overall, the annual median area burned in Region 10 during the 40 years, 1940-79, was only 53 acres (21 ha); the median number of fires was 25, most of which did not exceed class size A (¼ acre [0.1 ha]). Only 12 of the total reported fires were attributed to lightning; these, all in the Tongass National Forest, burned a total of 2 acres (1 ha). More than 2,500 acres (1 000 ha) burned within or near the Chugach National Forest in 1950 and again in 1959 and 1969; nearly 1,500 acres (600 ha) burned in the south Tongass area in 1958.

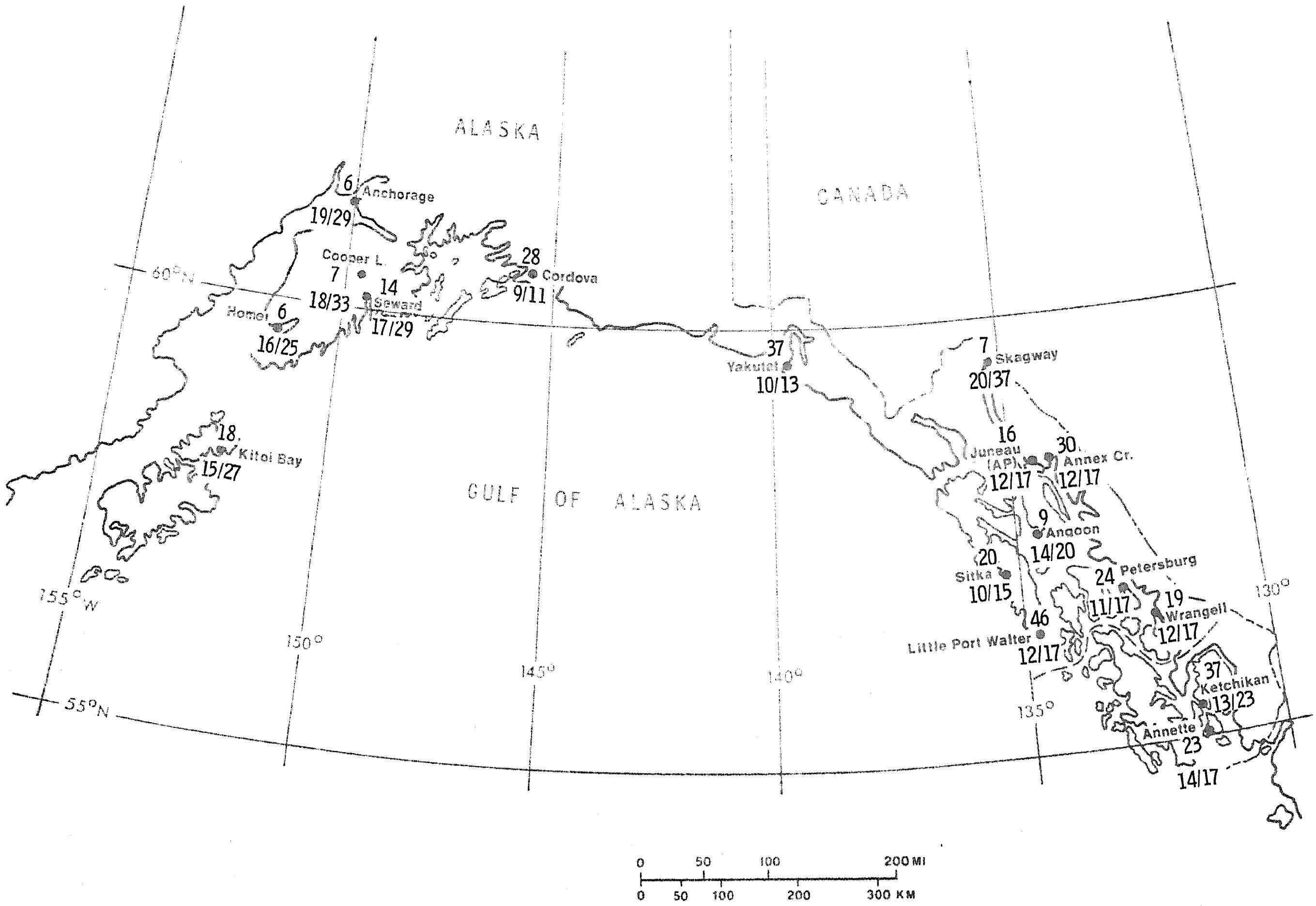

Figure 3.—Lengths of dry spells, arbitrarily defined by absence of 24-hour rainfall >0.04 inch (1.0 mm). Lower left number is average seasonal (May-August) maximum length, in days, based on 10-year sample, 1962-71; lower right number is 10-year extreme length. Top number is average 4-month rainfall, inches, for same period.

METHOD, DATA

In order to delineate fire-climate zones for coastal Alaska, it was first necessary to derive the fire-climate classes comprising these zones. To derive the classes in the context of wildfire potential and, also, to utilize simple climatic data providing greatest areal coverage, the following procedure was employed. Average daily maximum temperature for the May-August season and the average 4-month total rainfall were chosen as the climatic parameters. A multiple regression relationship was calculated between these (the independent variables) and a parameter of fire danger (the dependent variable), using the relatively small number of stations for which the latter item could be obtained. The regression was then applied, as a series of curves, to the temperature and precipitation averages at about 100 additional stations. This gave estimated values of the fire-danger parameter. The fire-climate class limits were set in terms of this parameter.

The climatic averages were compiled primarily from summaries published by the U.S. Department of Commerce, Weather Bureau (1958; 1965), and the Weather Bureau's successor agency, the National Oceanic and Atmospheric Administration (NOAA 1973a,b); data since 1960 were tabulated from Climatological Data monthly summaries for Alaska. Additional averages were obtained from the Federal Power Commission and the USDA Forest Service (1947), Patric and Black (1968), and from printout of a tape at the National Fire Weather Data Library at Fort Collins. For greater comparability among stations, the averages were adjusted, where required or possible, to represent the standard 30-year normal period 1941-70. The adjustment entailed use of the "difference method" for temperature and "ratio method" for rainfall (Oliver 1973). Resulting May-August values have been plotted to nearest whole numbers in figures 4 and 5. (See footnote 2 for station names and monthly details.) No adjustment was made in the temperature averages for effects of differing observation times (Rumbaugh 1934). At airport stations, data are for the actual calendar day; at most other stations, for the 24 hours ending near 4 or 5 p.m. Average maximums in the latter case may be at least 1.0° F (0.6° C) too high.

The parameter of fire danger was based on the former BUI, namely the average May-August number of days with a value of 30 or higher. Significance of this value was mentioned earlier. The data were extracted from the reference in footnote 1 and checked with BUI tabulations by Trigg and Noste (1969). As seen in figure 6, the above numbers of days correlate closely with the May-August average BUI values obtained from the Trigg and Noste (1969) reference. Though the BUI has been replaced operationally, past BUI data as employed here can serve as a useful indicator of fire-climate zones.

Efforts to use a fire-danger parameter from the current National Fire-Danger Rating System (Deeming and others 1977), namely the Energy Release Component (ERC), were abandoned. The ERC values were quite different for different periods of years, contrary to the trends of temperature and rainfall. For example, the 90th percentile ERC at Juneau (Federal Building) during 1968-72 was 26, with average 4-month rainfall 23.0 inches (584 mm); during 1973-79, the corresponding percentile from Juneau airport data was 0, with rainfall (at this drier location) 16.7 inches (423 mm). At Sitka airport, the 1968-72 figures were 21 for the ERC and 16.4 inches (417 mm) for rainfall; the 1973-79 figures were 3 and 15.1 inches (384 mm). The ERC value at Ketchikan changed from 18 to 8, and at Thorne Bay from 25 to 16. Much of the problem appears to lie in assumptions that had to be made by the FIRDAT program (Furman and Helfman 1973). The weather observations available prior to 1973 did not contain some items, such as precipitation duration, important for the ERC computations.

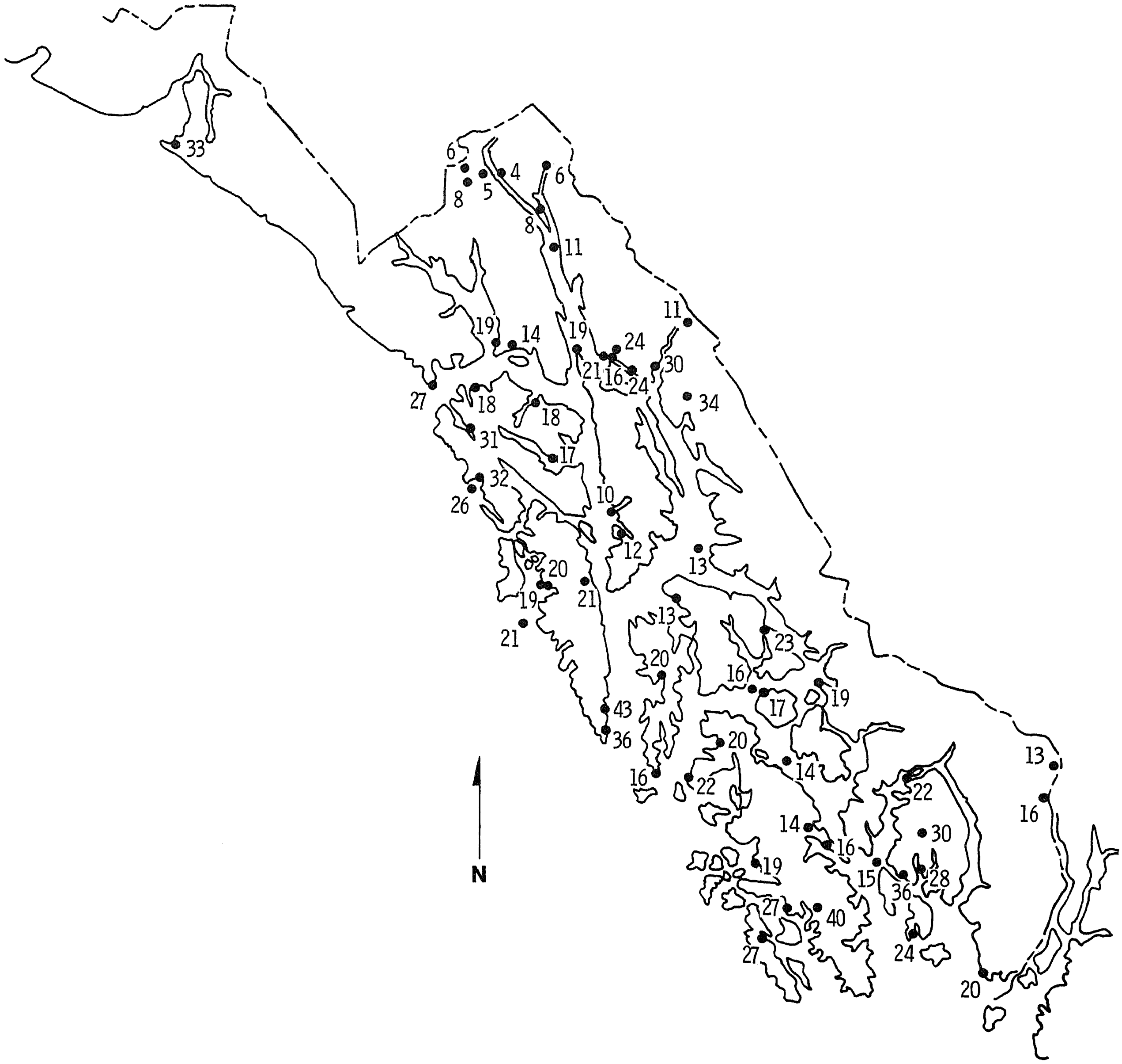

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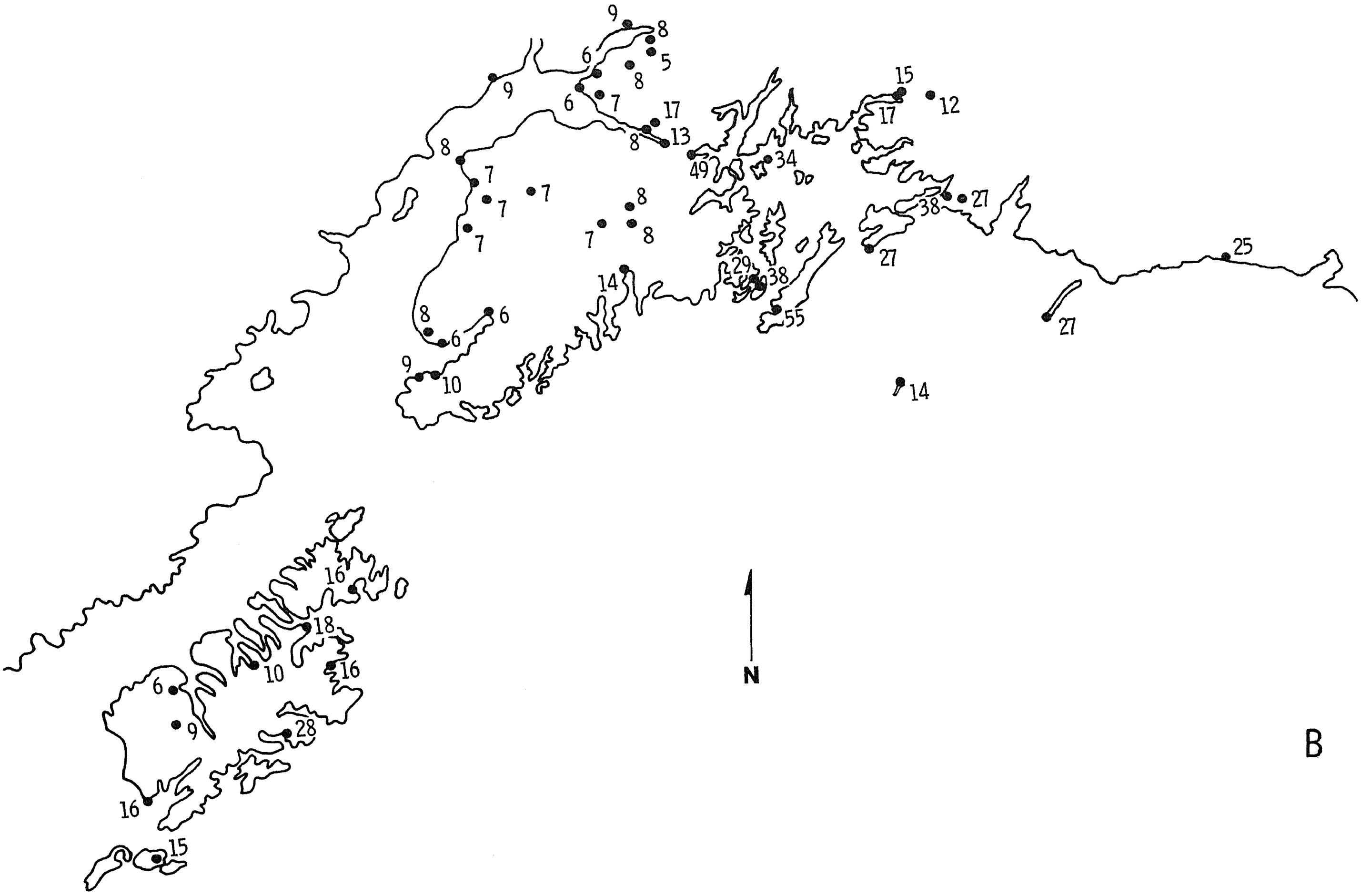
Figure 4.—Average May-August (4-month) rainfall, inches, at stations in coastal Alaska, mostly based on or adjusted to normal period 1941-70. Panel A: southeastern panhandle; panel B: Kenai Peninsula and south coast area.



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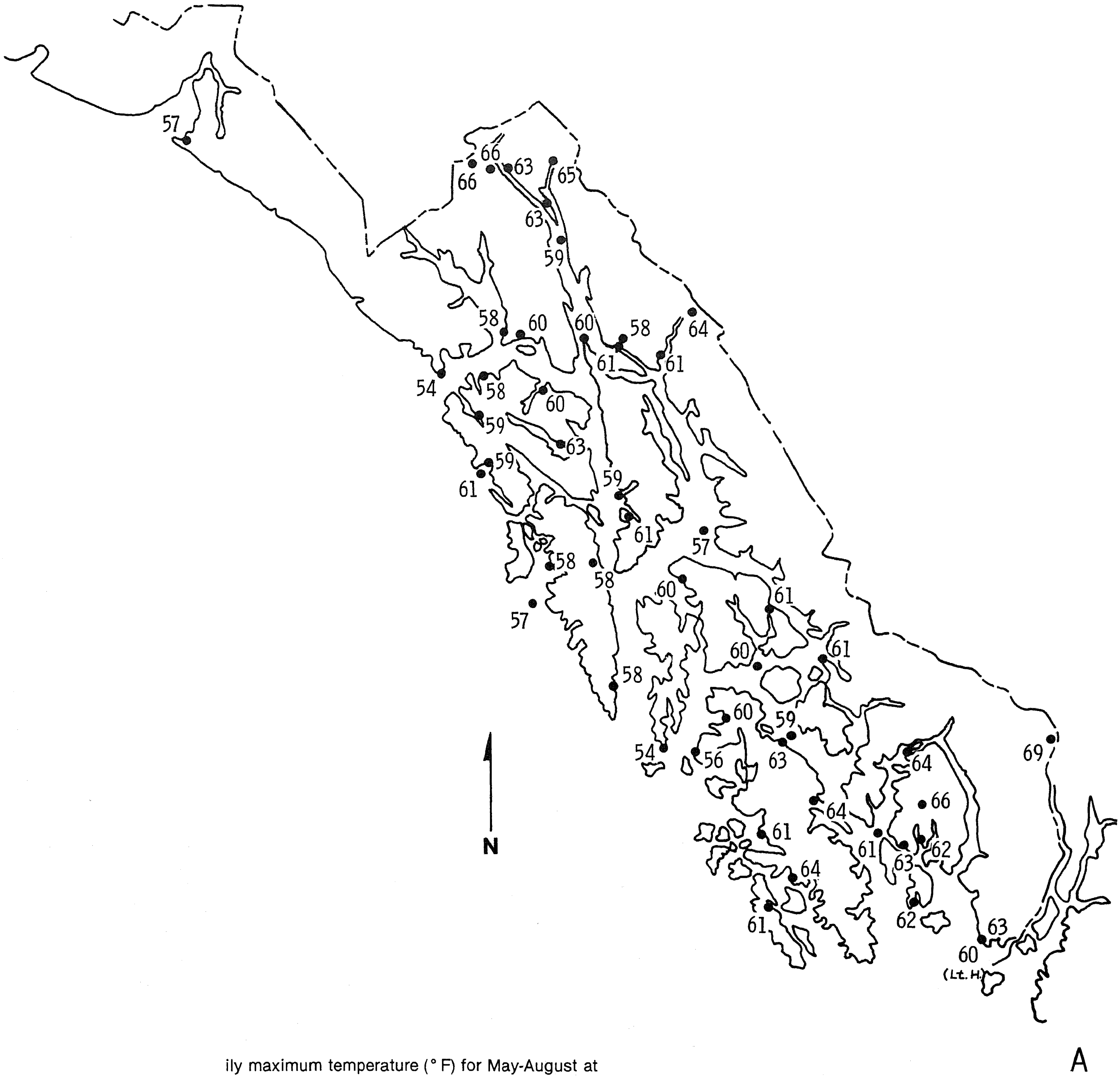

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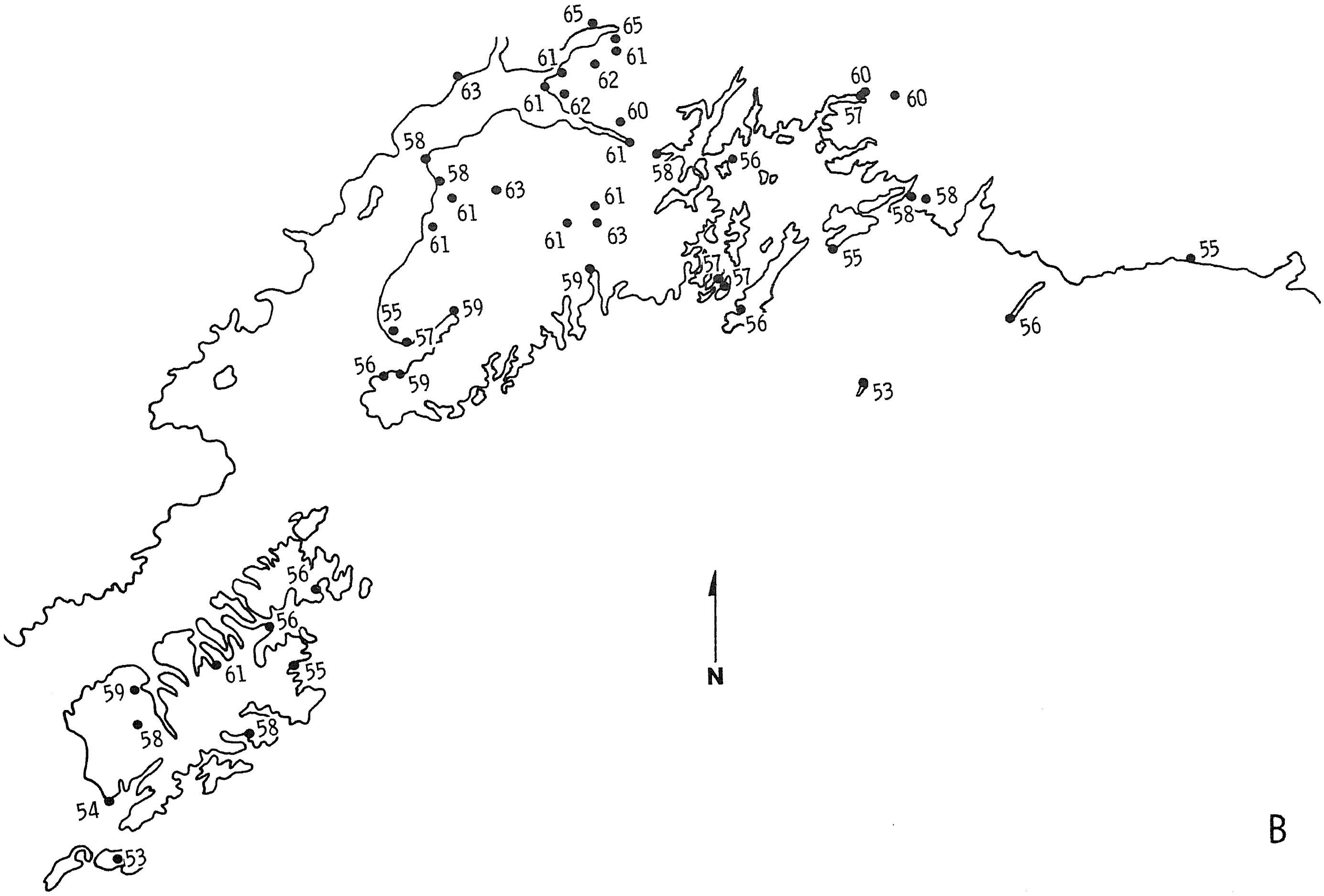

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The Fire-Climate Classes and Zones

The derivation of fire-climate classes considered the total number of days, 123, in the May-August fire season. The driest class was arbitrarily defined as having BUI-30 occurrence on one-half or more of all days; the lower limit was rounded to 60 days. For other classes, limits were successively halved to 30 and 15 days. A final, wettest class had an upper limit set at 5 days. This nearly geometric progression concentrates the fire-climate distinction within the range of BUI-30 days covering most of coastal Alaska. The excessive upward trend of the curves already noted in figure 8 occurs mostly outside the range of observed data. Where unrealistically high numbers of BUI-30 days are obtained, the fire-climate class may still be correct, due to the large leeway within the driest class.

The fire-climate classes, included in figure 8, have been named (and abbreviated) as follows: dry (D), moderately dry (MD), moderately wet (MW), wet (W), and extremely wet (XW). The driest class is dry in a relative sense; no stronger designation could realistically be applied anywhere in coastal Alaska.

Based on figure 8 and the temperature and rainfall averages shown in figures 4 and 5, the fire-climate zones have been drawn in figure 9. The boundary lines are, necessarily, generalized. They are drawn to closely fit the BUI results, for stations near sea level, but follow the larger scale topographic features and their inferred influences. The zones refer mainly to the lower elevations of the forest belt.

Summertime upper-air data, available from Anchorage, Annette, and Yakutat (and examined in footnote 2), indicate that the dominant Pacific airmasses usually extend throughout the forest elevations. Nighttime surface temperature inversions from radiational cooling do occur, but "marine" inversions (above which the air is warmer day and night and also much drier) are infrequent. This evidence, together with an indicated increase in precipitation with elevation (Federal Power Commission and USDA Forest Service 1947; Walkotten and Patric 1967; Schmiege and others 1974), suggests that in general the fire danger buildup decreases with elevation.

The features seen in figure 9 include: (1) a moderately wet zone, up to about 50 miles (80 km) wide, extending through nearly the entire length of the southeastern Alaska panhandle. This zone is situated between wet or extremely wet zones toward the west and east; (2) imbedded moderately dry pockets on at least two of the islands (Admiralty and Prince of Wales); (3) dry or moderately dry areas along the inlets and river valleys in the extreme northern panhandle and extreme east (along the Portland Canal and Taku River); (4) a dry zone covering most of the Kenai Peninsula west of the Kenai Mountain Divide; (5) a strong gradient across this divide to wet and extremely wet zones covering all of the south coast area; and (6) a wet zone over eastern Afognak Island (north of largely unforested Kodiak Island), with a moderately wet zone inferred over inland and sheltered portions to the west.

The pattern in figure 9 roughly follows that of annual precipitation (see fig. 2). In this generalized portrayal of zones, there is no attempt to show an apparent XW zone in the Coast Mountains (for example, east of Juneau and Petersburg), which would not include much forested area.

SUMMARY

This report has presented a method that was used to delineate fire-climate zones in the coastal Alaska area. Climatic data input consisted of simple averages—those of 4-month rainfall and daily maximum temperature during the May through August fire season. Fire-climate classes comprising the zones were derived by a multiple regression using the climatic averages and a fire-danger parameter at 18 stations. This parameter, from a former National Fire-Danger Rating System, was the average number of days with a BUI of 30 or greater (number of BUI-30 days); the value of 30 was previously found to be a threshold with respect to fire suppression in logging slash in coastal Alaska. The regression had high statistical significance; with all data converted to logarithms, the multiple correlation coefficient was 0.95. Curves based on the regression equation were applied to the climatic averages at more than 100 stations.

Five fire-climate classes were defined with limits generally based on a doubling of the number of BUI-30 days; divisions are at 60, 30, 15, and 5 days. The classes are termed dry (D), moderately dry (MD), moderately wet (MW), wet (W), and extremely wet (XW). The delineated fire-climate zones generally represent the lower forested elevations, though the boundaries follow the large-scale topographic features and their inferred influences. The fire-danger buildup in this region appears to usually decrease with elevation (away from open coasts). This is implied by temperature and humidity data from regular upper-air soundings, together with an indicated increase in precipitation with elevation.

Dry zones were defined over most of the Kenai Peninsula west of its major divide and in the extreme northern interior of the panhandle. A few moderately dry areas are found further south in the panhandle—between W or XW zones toward the Pacific Ocean and the eastern mountains—and along river valleys of the extreme east.

The method described here may employ a fire-danger parameter from the current national system. In the present case, lacking much of the required data, such a parameter could not be reliably calculated. The author does not believe that there is as yet one best method or approach; much may depend on the geographic (or broad climatic) region, as well as the type, amount, and quality of data available. In any method, however, defined fire-climate zones should ideally relate to an actual fire-danger index or parameter.

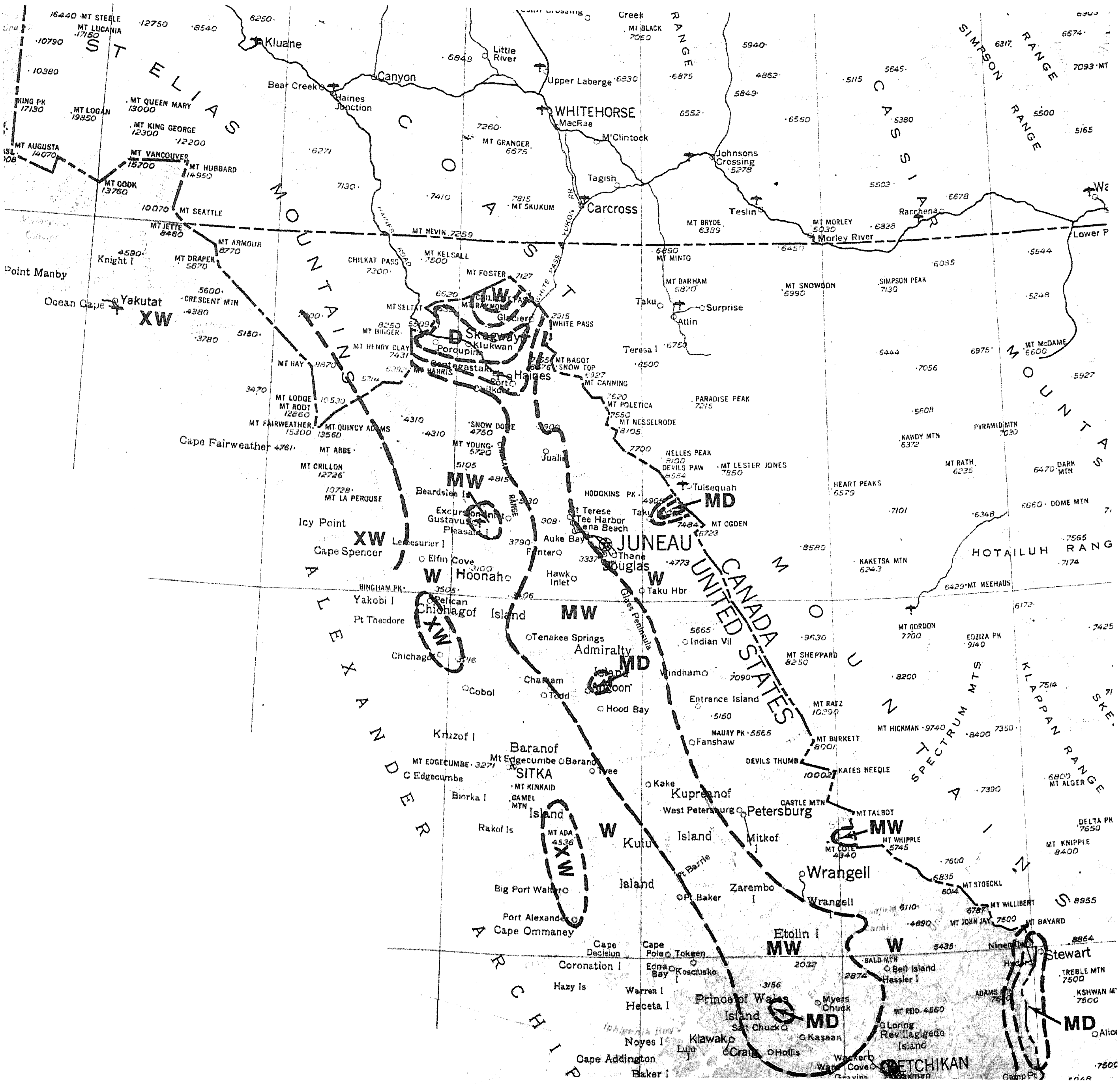
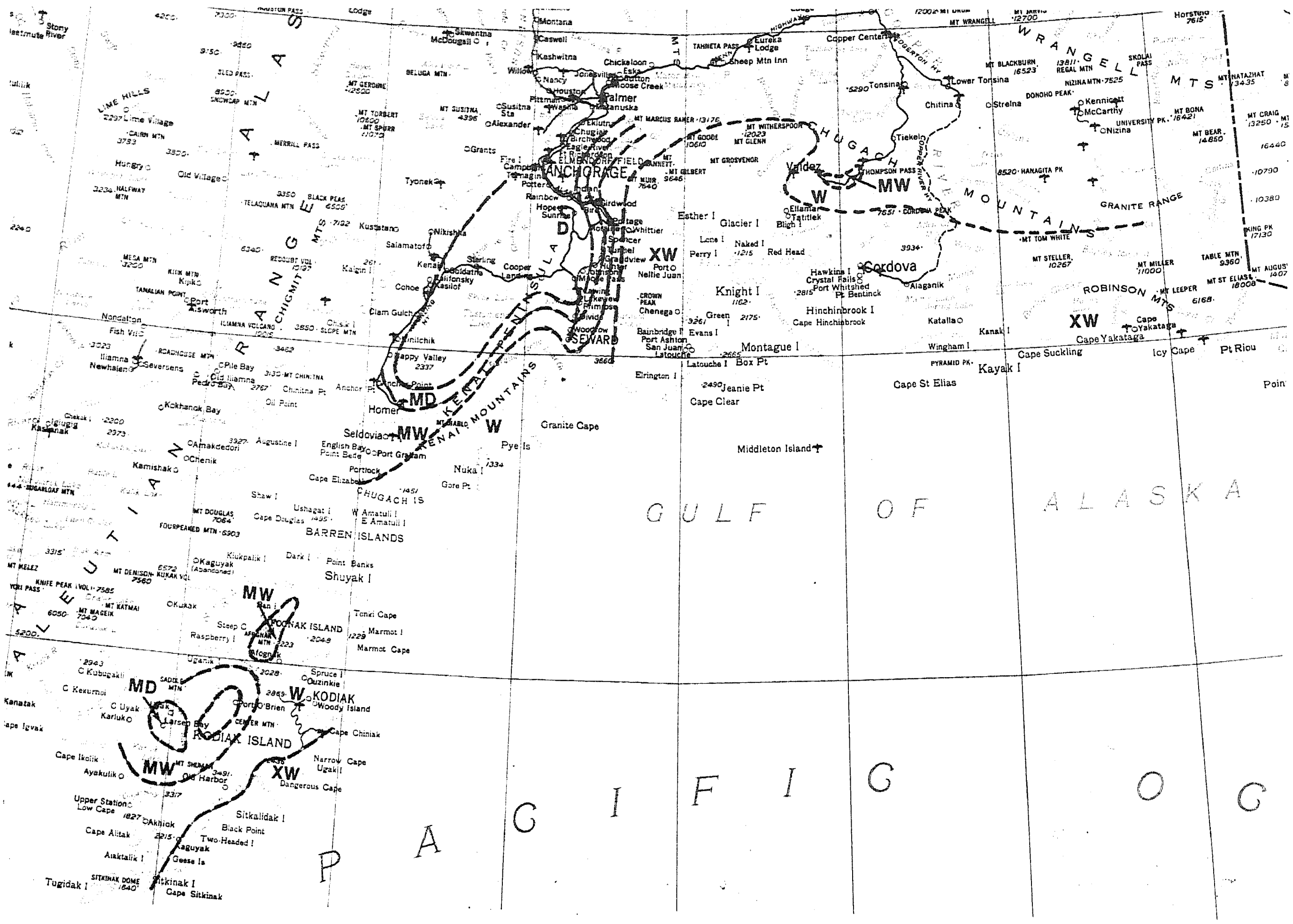


Figure 9.—Fire-climate zones delineated (by dashed lines) for co
Alaska. Panel A: southeastern Alaska; panel B: Kenai Peninsula
coast area. D denotes dry; MD, moderately dry; MW, moderately
XW, extremely wet.



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Delineates fire-climate zones for coastal Alaska (Forest Service, Region 10). The zones are based on five fire-climate classes derived through multiple regression using simple climatic averages—May-August rainfall and daily maximum temperature—and a parameter of fire danger. The regression, based on data from 18 stations, was applied to the climatic averages from about 100 additional stations.

KEYWORDS: climate, fire-climate zones, fire-management planning

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Provo, Utah (in cooperation with Brigham Young University)

.eno, Nevada (in cooperation with the University of Nevada)